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Correlation between Forward Head Posture, Round Shoulder Posture, and Muscle Activity during the Shoulder Flexion and Abduction Task

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Purpose: This study was to investigate the effect of forward head posture (FHP) and round shoulder posture (RSP) on changes in muscle activities according to shoulder flexion and abduction tasks.

Methods: Twenty-two male subjects with no history of neurological, musculoskeletal surgery or injuries, or pain in the spine region within the previous 3-month periods were recruited for this study. Craniovertebral angle (CVA) and Scapula Index were measured before performing 90° abduction and flexion tasks holding a 3kg dumbbell. Muscle activities were measured during the tasks. All measurements except height of the acromion were carried out in a sitting position at the height of the subject's knee angle of 90 degrees, and two tasks were randomly performed with the arm that the subject mainly use to throw the ball. The abduction and flexion angles were checked by the examiner using a goniometer beside the subject.

Results: Correlation coefficient analysis between Scapular Index and upper trapezius muscle activity during shoulder abduction task showed significant positive correlation. No significant correlation was observed between CVA, Scapular Index, and other muscle activities.

Conclusion: FHP showed increased muscle activation, making it difficult to change muscle activity under lower loads, and RSP was correlated with UT activation in shoulder abduction. Therefore, in the RSP, the loaded shoulder abduction is considered a potential risk factor for increasing shoulder muscle tension. This paper proposes an approach to treating RSP before FHP.

Keywords: Forward head posture, Round shoulder posture, Muscle activity

INTRODUCTION

Forward head posture (FHP) and rounded shoulder posture (RSP) are known as poor neck and upper limb postures. This poor posture is observed in neck and shoulder pain patients and is considered an intrinsic risk factor. Poor postures, such as FHP and RSP, are a problem for office workers, but the popularization of smartphones has caused abnormal alignment in the neck and shoulder in many people.[1,2]

In FHP, an excessive extension of the upper cervical spine is associated with shortening of the upper trapezius (UT), cervical extensor muscles, sternocleidomastoids (SCM) and the levator scapulae muscles.[2,3] The rounded shoulder posture is associated with the shortness of pectoralis muscles, and protracted, anteriorly tilted, internally rotated scapula is observed.[3-5]

Forward head and round-shoulder postures are also associated with altered spine and scapular kinematics and muscle activities, resulting in increased muscle activity of neck and shoulder stabilizers.[2,6,7] The upward rotation of scapula is an essential component of the arm elevation (flexion or abduction). The primary upward rotator muscles include the serratus anterior (SA), upper trapezius and lower trapezius. These muscles contribute equally importantly to the upward rotation of the scapula, and function as proximal stabi-

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lizer to provide a stable attachment for distal mover.[4,8,9]

In previous studies, the response of the muscles involved in stabilization is necessary to maintain normal scapulohumeral rhythm and shoulder movement.[10] In addition, the head position affected muscle activity during reaching.[11] There was a difference in muscle activity in subject with and without shoulder girdle elevation during shoulder abduction 90°.[12] In addition, a previous study reported that the muscle activity was different in the subject with and without scapular instability in tasks loaded during 90° shoulder flexion.[13]

A FHP does not always imply an RSP, and vice versa. Furthermore, not everyone with FHP and RSP experiences pain.[14-16] Muscle activation changes in the FHP or RSP might lead to pain or dysfunction during the arm raising load task in a subject without pain. Previous studies reported that a decrease in craniovertebral angle (CVA) doesn't necessarily lead to an increase in RSP although FHP and RSP could simultaneously occur.[15,17] In other words, this study examined correlation between FHP, RSP, and muscle activity during the shoulder flexion and abduction tasks.

METHODS

1. Subjects

Twenty-two male subjects with no history of neurological, musculoskeletal surgery or injuries, or pain in the spine region within the previous 3-month periods were recruited for this study. The purpose and procedures of this study were explained to all subjects, and they are provided written informed consent prior to a participation. This study was approved by the Daegu University Institutional Review Board (approval number: 1041849-201907-BM-114-02).

2. Measurements

1) CVA

The CVA was determined as the angle between the horizontal line passing through C7 and the line extending from the tragus to C7.[18] A digital photo of the lateral view of the subject was taken three times to measure CVA after the skin overlying the spinous process of the seventh cervical vertebra (C7) and tragus of the ear was marked.[19] It is considered that the smaller CVA is, the more severe FHP is.

2) RSP

In order to assess RSP, scapular index was used. Both the distance from the medial aspect of the coracoid process (CP) to the midpoint of the sternal notch (SN) and the distance from the thoracic spine (TS) to the posterolateral angle of the acromion (PLA) were measured three times in the right side to determine the resting position of the scapula. In addition, the calculation of the Scapula Index was done using the following equation: [(CP to SN/TS to PLA) X 100].[20]

3) Surface electromyography

Electromyography (EMG) data were collected using a TeleMyo 2400 (Noraxon U.S.A., Inc., Scottsdale, AZ, USA). A sampling rate of 1,000 Hz was used for the raw EMG signal acquisition, and the signals were full-wave rectified. Band-pass filtering at 30-500 Hz was performed using the MyoResearch XP 1.07 (Noraxon U.S.A., Inc., Scottsdale, AZ, USA) software, and the signals were also notch filtered at 60Hz to remove noise. The Reference Voluntary Contraction (RVC) values were measured while the subject maintained both 90° abduction and 90° flexion in order to normalize the EMG data. The RVC data were collected for 5 seconds in two trials. The middle 3 seconds of each 5 second trial were used. The collected EMG data were calculated as percentages of RVC (%RVC). The muscle activation of each muscle was measured three times, and raw data was converted to RMS (root mean square) to normalize the calculated values of each muscle and the mean value of three repeated values was measured to analyze and compare the muscle activation. The electrodes were placed on seven muscles: the sternocleidomastoid muscle, the pectoralis minor muscle, the serratus anterior muscle, the splenius capitis muscle, the upper trapezius muscle, the middle trapezius muscle, the lower trapezius muscle. All the measurements were described as mean value ± standard deviation.

For the sternocleidomastoid muscle, the electrodes were placed at the point one third of length rostral to the sternal attachment. For the pectoralis major muscle, the electrodes were placed at the point 2cm out from the axillary fold. For the serratus anterior muscle, the electrodes were placed vertically along the mid-axillary line at the level of rib 6-8. For the splenius capitis muscle, the electrodes were placed at the point 3cm below the mastoid process, between the uppermost parts of the trapezius and sternocleidomastoid. For the upper, middle, and lower trapezius muscles, the electrodes were placed at the level of c5-c6 about 2cm lateral from the midline, midway between a straight line connecting c7 spinous process to the acromion, and a point 5cm inferomedial from the root of the spine of the scapula, respectively.[21-23]

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3. Experimental Procedure

CVA and Scapula Index were measured before performing 90° abduction and flexion tasks holding a 3kg dumbbell, a low load that all subjects can easily lift. Muscle activities were measured during the tasks. All measurements except height of the acromion were carried out in a sitting position at the height of the subject's knee angle of 90 degrees, and two tasks were randomly performed with the arm that the subject mainly use to throw the ball. The abduction and flexion angles were checked by the examiner using a goniometer beside the subject.

4. Statistical analysis

All statistical analysis was conducted using SPSS for Windows version 24.0 (IBM, Inc., Chicago, IL, USA). The normality of distributions was tested using the Kolmogorov-Smirnov method. Pearson correlation coefficients were used to examine the degree of correlation between CVA, Scapula Index, and muscle activities during shoulder abduction and flexion tasks. The level of statistical significance was set at α = 0.05.

Table 1. Measured values of CVA, right scapular index

CVA	RT SI
50.43±4.78	66.19±5.51

Values are reported as the Mean±standard deviation. CVA: craniovertebral angle, RT SI: right scapular index.

Table 2. Muscle activities during 90° abduction and flexion tasks (Unit: %RVC)

	SCM	PEC	SER	SPL	UP	MID	LOW
Abduction	103.70±34.73	77.48±27.38	138.06±31.48	153.88±45.69	187.34±60.27	200.39±81.12	139.44±48.17
Flexion	76.16±26.47	68.61±22.73	138.08±38.61	140.37±25.72	168.25±37.04	149.02±30.73	161.57±73.84

Values are reported as the Mean±standard deviation. SCM: sternocleidomastoid, PEC: pectoralis major, SER: serratus anterior, SPL: splenius capitis, UP: upper trapezius, MID: middle trapezius, LOW: lower trapezius.

Table 3. Correlation between CVA, scapular index, and muscle activities during 90° abduction tasks

	CVA	RT SI	SCM	PEC	SER	SPL	UP	MID	LOW
CVA	1								
RT SI	-0.419	1							
SCM	-0.215	-0.012	1						
PEC	-0.146	0.421	0.364	1					
SER	-0.060	0.192	0.141	0.396	1				
SPL	0.008	-0.204	0.161	0.011	-0.006	1			
UP	-0.090	0.613*	-0.094	0.110	0.029	0.326	1		
MID	-0.451	-0.108	0.585	-0.043	-0.117	0.569	0.433	1	
LOW	0.183	-0.338	0.034	-0.212	0.013	-0.021	-0.311	-0.057	1

*p<0.05, Values are reported as the Mean±standard deviation. CVA: craniovertebral angle, RT SI: right scapular angle, SCM: sternocleidomastoid, PEC: pectoralis major, SER: serratus anterior, SPL: splenius capitis, UP: upper trapezius, MID: middle trapezius, LOW: lower trapezius.

Table 4. Correlation between CVA, scapular index, and muscle activities during 90° flexion tasks

	CVA	RT SI	SCM	PEC	SER	SPL	UP	MID	LOW
CVA	1								
RT SI	-0.419	1							
SCM	-0.407	0.175	1						
PEC	0.094	-0.349	-0.342	1					
SER	0.333	-0.517	-0.199	0.304	1				
SPL	0.178	-0.430	-0.015	0.091	0.062	1			
UP	-0.102	-0.255	0.000	0.200	-0.118	0.445	1		
MID	-0.176	0.091	-0.134	0.316	0.015	0.007	0.295	1	
LOW	-0.384	0.022	0.321	-0.141	-0.151	-0.050	0.001	0.520	1

*p<0.05, Values are reported as the Mean±standard deviation. CVA: craniovertebral angle, RT SI: right scapular angle, SCM: sternocleidomastoid, PEC: pectoralis major, SER: serratus anterior, SPL: splenius capitis, UP: upper trapezius, MID: middle trapezius, LOW: lower trapezius.

RESULTS

All participants were right-handed. The mean age, height, and weight of the participants were 50.4±4.8 degrees, 21.5±1.1 years, 166.9±9.3 cm and 70.0±8.4 kg, respectively. CVA and scapular index were 50.43 ±4.78 degrees and 66.19±5.51, respectively (Table 1). Activities of the sternocleidomastoid muscle, the pectoralis minor muscle, the serratus anterior muscle, the splenius capitis muscle, the upper trapezius muscle, the middle trapezius muscle, the lower trapezius muscle were 103.70±34.73, 77.48±27.38, 138.06±31.48, 153.88±45.69, 187.34±60.27, 200.39±81.12, and 139.44±48.17 during abduction task, 76.16±26.47, 68.61±22.73, 138.08±38.61, 140.37±25.72, 168.25±37.04, 149.02±30.73, and 149.02±30.73 during flexion task, respectively (Table 2). Correlation coefficient analysis between Scapular Index and upper trapezius muscle activity during shoulder abduction task showed significant positive correlation ($r=0.613$, $p<0.05$). No significant correlation was observed between CVA, Scapular Index, and other muscle activities (Tables 3, 4).

DISCUSSION

Correlation coefficient analysis between the Scapular Index and upper trapezius muscle activity during the shoulder abduction task showed a significant positive correlation. No significant correlation was observed between the CVA, Scapular Index, and other muscle activities. This study showed that the FHP and RSP affect the muscle activity around the shoulder, such as Trapezius, serratus anterior, pectoralis, and neck extensor muscle, by comparing with a flexion and abduction of the shoulder. As a result, there was no correlation between the FHP and RSP, showing that the FHP and RSP were not correlated with the changes in muscle activity during the flexion task. There was no correlation between the FHP and muscle activation change during the abduction task. On the other hand, it was associated with increased muscle activation of the upper trapezius and RSP. As a result, there was no correlation between FHP and RSP. In a previous study, the FHP was not related with increased thoracic curvature or upper cervical spine extension.[24] Depending on the degree of forward head posture, changes were detected in the neck disability indices, but even an increase in the forward head tilt angle did not lead to RSP.[15] However, mild FHP (CVA=47-50 degrees) did not increase RSP in the present study as in previous studies. Also, a previous study reported that angle measurement between anatomical references is more effective for evaluating head/shoulder posture.[18,25]

This study found no correlation between FHP and change in muscle activation during flexion and abduction task. Previous studies observed increased activity in the upper and lower trapezius (UT and LT) and decreased activity in the serratus anterior (SA) during loaded shoulder flexion with FHP.[26] In addition, increased activity in UT was noted, but there was no significant difference between SA and LT during loaded shoulder abduction with FHP.[27] Furthermore, increased activity in the UT and pectoralis major but decreased activity in the SA and middle trapezius were observed during shoulder abduction with FHP.[28] In this study, however, there was no correlation between FHP and the difference in muscle activation during shoulder flexion and abduction. In previous studies reported that FHP changed according to the muscle length and muscle tension, such as sternocleidomastoid, neck extensor, trapezius, SA, and pectoralis.[7,29-31] In FHP, increased muscle activation of the UT and decreased muscle activation of the SA were noted during shoulder flexion and abduction.[26-28,31] On the other hand, there was no difference in muscle activation during shoulder flexion and abduction according to low load because it already has increased activity of the UT, decreased activity of SA, and lower endurance in FHP.[30,31] Because of mild FHP, it is suggested that there might be no significant correlation between FHP and muscular activation in the present study. In addition, when the posture is stable, the muscle activity increased in the SA and pectoralis major as the load increased, but the UT showed constant muscle activity.[32] And the upright sitting posture reduced muscle activation of UT.[33] In the present study, an upright posture was induced because the task was performed in a chair without back support, and it might have been able to have an influence on the results.

No correlation was observed between the RSP and the difference in muscle activation in the shoulder flexion according to load, but a correlation was noted between RSP and the difference in muscle activation of the UT in the shoulder abduction according to load. Previous studies reported decreased muscle activation of SA in shoulder dysfunction and scapular instability.[10,34] In addition, increased muscle activity of the UT was observed to compensate for the weakness of the SA.[10,35] When providing scapular stability, there was no significant difference in the activity of the UT to shoulder flexion during scapular protraction exercise.[36] Furthermore, the strength of

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the shoulder flexor increased during shoulder flexion.[13] Because the RSP is associated with protracted, anteriorly tilted, internally rotated scapula.[3,5] It is believed that there was no increase in muscle activation at low loads because of the scapular stability caused by passive tension of the muscle acting on anterior tilt during shoulder flexion. The SA and the UT acts as the abductor and elevator of scapular, respectively,[37] and the SA and UT are related to the upward rotation of the scapula during the shoulder flexion.[26] Therefore, shoulder abduction requires more scapular stability than shoulder flexion in RSP, which correlates with the muscle activation of the UT and RSP.

Several limitations of this study require consideration. This is difficult to generalize because of the exclusion of severe FHP and RSP and the small number of experiments. Prospective studies should consider the severe FHP and RSP, and forward head and rounded shoulder posture (FHRSP) rather than each posture. In conclusion, FHP showed increased muscle activation, making it difficult to change muscle activity under lower loads, and RSP was correlated with UT activation in shoulder abduction. Therefore, in the RSP, the loaded shoulder abduction is considered a potential risk factor for increasing shoulder muscle tension. This paper proposes an approach to treating RSP before FHP.

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